PLANT GROWTH & DEVELOPMENT

- All plants —descendants of→ Zygote
- Growth + Differentiation = Development (sum)
- Zygote. —follow a precise & highly ordered succession of events→ Mature plant (complex body organ. - Roots, Leaves, branch, flow.)
  - Mature plant —eventually→ Die
- 1st step in plant growth: Seed germination
  - When fav. cond. for growth exists → Seeds resume metabolic activity & growth occurs.
  - If absent → Seeds do not germinate & goes into a period of suspended growth or rest. —Once cond. returns→ Seeds resume metabolic activity & growth occurs.

GROWTH: → conspicuously involves increased protoplasmic material.

- Most fundamental & conspicuous charact. of living beings.
- ① Irreversible ② permanent increase in size of an organ or its parts or even of an indiv. cell.
- Growth —accompanied by→ Metabolic activities → occur at the expense of energy.
  - both: Catabolic, Anabolic

Example → expansion of leaf.

- PLANT GROWTH GENERALLY IS INDETEMINATE: → Imp.

Plant growth —Unique→ Retain the capacity for unlimited growth throughout life

because of.

- presence of meristems at certain locations in their body.
- capacity to divide & say perpetuate

Root apical meristem
Shoot apical meristem
Intercalary meristem
→ contribute to elongation growth of plant axes.

The product → loses the capacity to divide & such cells make up plant body.

* open form of growth pattern

→ Root & shoot apical meristem. → primary growth of the plants → elongation along plant axis.

→ Dicots & Gymnosperm → Lateral meristems

Causes increase in girth of organs where they are active. → secondary growth.

Vascular camb.
Cork Cambium

GROWTH IS MEASURABLE:

Growth → at cellular level → (consequence) → increase in amt of protoplasm

difficult to measure directly hence one measures some quantity which is more or less proportional to it.

1) increase in
① fresh weight
② dry weight
③ Length ④ Area
⑤ Volume ⑥ Cell number.

→ One single Maize Root apical meristem → (give rise) → > 17,500 new cells per hour
Increase in cell number.

→ Cells of watermelon → (may increase in size) → upto 3,50,000 times
Increase in size of cell

→ Growth of pollen tube → In terms of length

→ Growth in adorsiventral leaf → in terms of surface area.

Phases of Growth:

Meristematic

- Cells rich in protoplasm
- Possess large conspicuous nuclei
- Cell walls - primary thin Cellulosic With plasmodesmatal connection (many)

Eg. Constantly dividing cells, both at root apex & shoot apex.

Elongation

- Increased vacuolation
- Cell enlargement
- New cell wall deposition

Eg. Cells proximal to meristematic zone.

Maturation

- Cells in maximal size in terms of
  - Wall thickening
  - Protoplasmic modific.

Eg. Cells proximal to elongation zone

Proximal → away from tip.

Growth Rates: → expressed mathematically.

Growth ↑ per unit time

Two types of growth:

ARETHMETIC

Following mitotic cell division only one daughter cell divide and other differentiates & matures.

Eg. Root Elongating at a constant rate.

$L_t = L_0 + rt$

r → growth rate/ elong. per unit time

GEOMETRIC.

In initial stage, growth is slow (Lag phase)

↓

then ↑ rapidly at exponential rate (log/exponential phase)

Here both the progeny cells follow mitotic cell division & retain the ability to divide & so on.

↓

With limited nutrient supply, growth slows down (Stationary phase)

$W_t = W_0 e^{rt}$

r → efficiency index

Relative growth rate measure of the ability of plant to prod. new plant mate

e → base of natural logarithms

DEVELOPMENT:

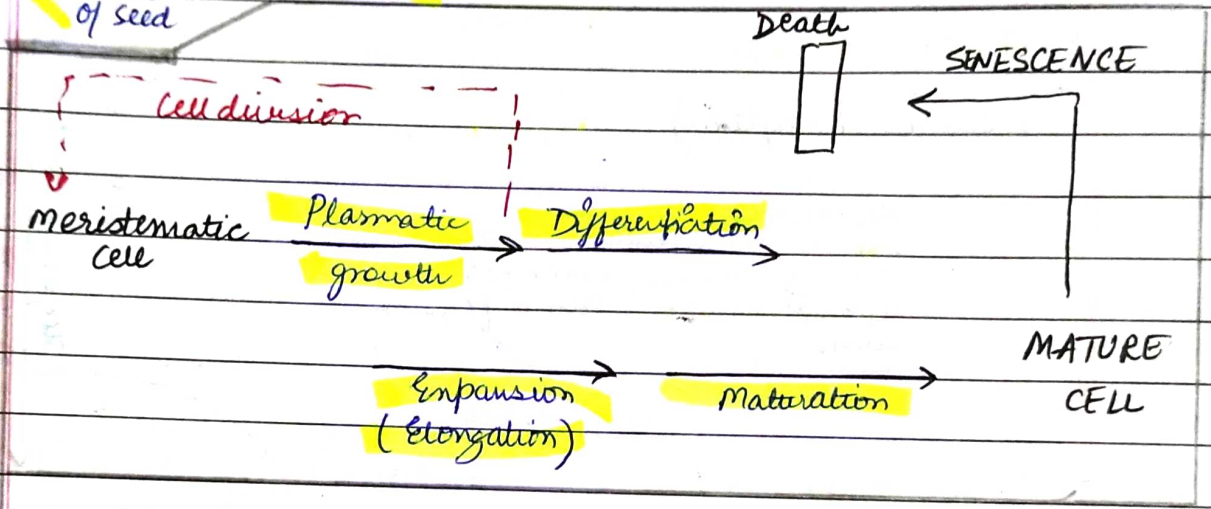
↓ Includes

All changes that org. goes throughout life cycle

* Applicable to tissues & organs also.

↓

from germination of seed → Senescence.



Parts follow diff pathway → In response to environm. or phases of life → To form different kind of structures

(This ability = Plasticity)

Example.

Heteroplylly in Buttercup

- Shape of leaves in air
- Shape of leaves in water

Example

Heteroplylly in cotton, Coriander, Larkspur.

- leaves of juvenile different in shape
- Mature leave shape differ.

* Thus Growth, differentiation & development very closely related events in plant life.

Development- under control of

Intrinsic fact:

① Intracellular (genetic)
or
② Intercellular (PGR)

Extrinsic fact.

Temp., water, oxygen & nutrition.

Roles of PGR could be Complimentary Or antagonistic.
These could be individualistic or synergistic.

Role of PGR → intrinsic control
↳ Along with genomic & external factors
↓
Imp role in plant growth & development.
↓
Many extrinsic factors such as temp & light control plant growth & develop via PGR
↓
1) Vernalisation
2) flowering
3) Dormancy
4) Seed germination
5) Plant movement.

PHOTOPERIODISM: → The critical duration is diff. for differ. plants.

- Some plants require periodic exposure to light to induce flowering.
- Plants are able to measure duration of light

Long day plants | day-neutral plant | Short day plants

* Duration of dark period is also important.
* Flowering in certain plants depends not only on the combination of light & dark exposures but also their relative durations.

- The response of plants to periods of day/night.

→ Shoot apices —modify (before flowering)→ flowering apices

→ Cannot perceive photoperiods

★ The site of perception of light/dark duration are → Leaves.

Hypothesised → hormonal substance → responsible for flowering

→ migrate from Leaves → shoot apices

↓

Induces flowering

Only when the plants are exposed to the necessary inductive photoperiod.

VERNALISATION → Promotion of flowering by a period of low temperature

Flowering – Quantitatively or Qualitatively dependent on exposure to low temp

* It prevents precocious reproductive development late in the growing season, and, enables the plant to have sufficient time to reach maturity.

Imp Food plants: "Wheat & Barley" "Rye"

have two kinds of varities

Winter variety

↓

If planted in spring would normally fail to flower / or produce mature grain within a span of flowering season.

Planted in: Autumn.

Germinate: Over winter

* Come out as small seedling

Resume growth: in Spring

Harvested: Around mid summer.

Spring variety

↓

Planted in: spring

Flower/grain in: Before the end of growing season.

Another example of vernalisation → Biennial plants → Are MONOCARPIC → Normally flower & die in 2nd season.

- Sugarbeet
- Cabbages
- Carrots.

* Subjecting the growing of biennial plant to a cold treatment stimulates a subsequent photoperiodic flowering response.

SEED DORMANCY.

Certain seeds → fail to germinate → when external cond. are favourable.

↓

Such seeds are going a period of dormancy

↓

Controlled 'not' by external env. but are "under" endogenous control. or cond. within seeds itself.

Reasons which causes dormancy:

1. Impermeable & hard seed coat.
2. Presence of chemical inhibitors such as
   - → abscisic acids
   - → phenolic acid
   - → Para-ascorbic acid.
3. Immature Embryos.

* Plants exhibit plasticity in development.

PGR - control different differentiation & development events.
→ have diverse physiological effect on plant.

Overcoming Dormancy

Natural means

Mechanical abrasions
- Microbial action
- Passage through digestive tract of animals.

Man-made / Artificial

Breaking seed coat barrier by → Vigorous shaking
→ Mechanical Abrasions
- Knives
- Sandpaper.

(*) Effect of inhibitory substance can be removed by subjecting the seeds to
- → chilling cond.
- → Application of chemicals
  - → GA
  - → Nitrates

(*) Changing Environment cond such as
- → light
- → Temp.

→ Other ways to overcome seed dormancy

(*) Growth may not be & generally is not sustained at high rate throught the life of cell/tissue/organ/organism.

(*) Differentiation results in development (→ flexible) of structures, that is commensurate with the function the cells finally has to perform.

General principles for differentiation of cells, tissue & organs are similar.

open in plants

small, simple molecule of diverse chemical composition.

PGR

- Indole cmp.
  - IAA
  - Indole-3-acetic acid
- Adenine derivat.
  - N^6-furfurylamino purine
  - Kinetin
- Carotenoids
  - ABA
  - Abscisic acid
- Terpenes
  - Gibberellic acid
  - GA_3
- Gases
  - Ethylene.

PGR

↓ Based on their function in a living plant body.

- **Plant growth promoters.**
  - Cell division
  - Cell enlargement
  - Pattern formation
  - Tropic growth
  - Flowering
  - Fruiting
  - Seed formation

  Eg. Auxin, Gibberellins, cytokinin.
- **Gaseous**
  - ↓ Ethylene.

  (could fit either of the groups but it is largely an growth inhibitor.)
- **Plant growth inhibitor**

  Plant responses to wounds & stresses of biotic & abiotic origin.

  Involved in growth inhibiting activities like dormancy & abscission

  Eg. ABA

Discovery of PGR.

"Discovery of each of the five PGR was have been accidental."

Auxin

→ F.W went isolated it from coleoptiles of oat seedlings

Charles darwin & son francis darwin observed

↓ Coleoptiles of canary grass responded to unilateral illumin. by growing towards light source. (Phototropism)

After a series of exp, it was concluded that the tip of coleoptile was the site of transmittable influence that caused bending of entire coleoptile.

Gibberellic acid

The 'bakane' (foolish seedling) disease of rice seedlings, was caused by fungus Giberella fujikuroi.

In 1926, E-Kurosawa reported appearance of symptoms of the disease in rice seedlings when they were treated with sterile filtrate of fungus.

active subst.

↓ Gibberellic Acid

Miller et all (1955) identified & crystallised this — Kinetin.

Cytokinin

F. Skoog & his coworkers found out that from the internodal segments of tobacco stems the callus (mass of undiff. cells) proliferated only if, in addition to auxin the nutrient medium was supplemented with either one:
1. Extract of vascular tissue
2. Yeast extract
3. Coconut milk of DNA

Abscisic acid

In mid 1960s
Three independ. researches.
↓ reported
purification & chemical characterization of three diff. kinds of inhibitor
↓ ↓ ↓
inhibitor-B dormin abscision II

Later all three were proved chemically identical
↓
ABA (abscisic acid)

Ethylene

H. H cousin (1910) confirmed release of volatile substance
↓
from ripened oranges.
that hastened ripening of unripe bananas.
↓
Ethylene (gaseous)

AUXIN (auxein : to grow) ▷ greek.

→ Isolated from : human urine

→ Auxin

- Indole-3-acetic acid (IAA)
- Certain compounds having certain growth regulating properties
  - Natural
    - IAA
    - IBA
    - ↓ Isolated from plants
  - Synthetic
    - NAA (Naphthalene acetic acid)
    - 2,4-D (2,4-dichloro phenoxyacetic)

* All these auxins have been used extensively in 1) agricultural 2) Horticulture.

Higher plants → Growing apical buds inhibit growth of lateral bud. (Apical dominance)

Removal of shoot tips (decapacitation)
↓
Growth of lateral buds.
↓
Widely applied in tea plant, hedge making.

→ Auxin
- → Initiate rooting in stem cuttings.
- → Plant propagation.
- → Flowering : In pineapples
- → Prevent fruit & leaf drop at early stage.
- → Promote abscission of older mature leaves & fruits
- → Parthenocarpy : In tomatoes.
- → Herbicides
  - ↓ 2,4-D → Widely used to kill dicotyledonous ~~weeds plants~~ but does not affect dicot plants.
    - ↓ Used to prepare weed free lawns by gardeners.
- → Cell division
- → Xylem differentiation

GIBBERELLINS

- Phytohormone PGR.
- More than 100 gibberellins (acidic) ← from Widely different Organism
  - Fungi
  - higher plants

GA$_1$ GA$_2$ GA$_3$ & so on.

GA$_3$:
- first discovered
- Most intensively used.

* GAs produce a variety of biological response in plants.

- → ability to increase in length of axis
  - → To increase length of grape stalks.
- → Apple, to elongate & improve its shape.
- → Delays senescence. (thus fruits can be left on tree longer to extend market period)
- → Speed up malting process in brewing industry.

Sugarcane : stores carbohydrates (as sugars) in their stems.
Spraying with gibberellins → ↑ length of stem.
↑ yield by 20 tonnes per acre.

Juvenile Conifers : Spraying these with gibberellins
↓
Hastens maturity period → thus → Early (speedy) seed production.

Beet, Cabbage & Plants with Rosette habitat : GA promotes bolting (internode elongations just prior to flowering

CYTOKININ → Richmond Lang Effect.

- Have special effects on cytokinesis
- Was discovered as Kinetin (a modified form of adenine, purine)
  - ↑ (from) Autoclaved herring sperm DNA.
  - does not occur naturally in plants.

Search for subst. (natural) with cytokinin like activities → led to → Isolation of zeatin from ① corn kernel ② Coconut milk.

- Since zeatin's discovery, several natural as well as synthetic comp. with cell division promoting activity have been identified

- Natural cytokinin found out in → region where rapid cell division occurs.
  - Root apices
  - Developing shoot buds
  - Developing/young fruits

- Cytokinin helps to produce → new leaves
  new chloroplast in leaves
  Lateral shoot growth
  adventitious shoot formation.

- Cytokinins helps overcome apical dominance.

- Help in nutrient mobilisation → helps in → delay of leaf senescence.

ETHYLENE

- Simple, gaseous PGR.
- Synthesized (in large quantities) by : Tissue undergoing senescence
  Ripening fruits.
- Its influences → Horizontal growth of seedlings
  Swelling of the axis
  Apical hook formation in dicot seedlings

- Ethylene → promotes senescence & abscission
  - leaves
  - flowers
  - Highly effective fruit ripening
  - Enhances resp. rate during ripening of fruits
    ↓
    a rise in the rate of resp (↑) → Respiratory Climactic
  - Breaks seed & Bud dormancy
  - Initiates germination in peanut seeds
  - Sprouting of potato tubers
  - Promotes rapid internode/petiole elongation in deep water rice plant. It helps leaves/upper parts of the shoot to remain above water
  - Root growth → Root hair formation → surface area ↑
  - (I) → Initiates flowering & synchronising fruit set in pineapples.
  - (II) → Induce flowering in mango

  Regulates many physiological processes
  ↓
  most widely used in agriculture horticulture.

- Source : Ethephon → aq. soln → readily absorbed & transported within the plant & releases ethylene slowly.
- Ethylene Hastens fruit ripening
  - Tomato
  - Apples
  - ⊙ accelerates abscission in flowers & fruit (Thinning of cotton, cherry, walnut)
  - ⊙ Promotes female flowers in cucumber & thereby increasing yield

ABSCISIC ACID

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- Has role in regulating abscission & dormancy.
- Plant growth inhibitor & an inhibitor of plant metabolism.

- Inhibits seeds germination.
- Stimulates closure of stomata in epidemis

↓

Increases tolerance of plants to various kind of stress

↓

"Stress hormone"

→ antagonistic to GAs.

(ABA)

- Seed develop.
- Maturation
- Dormancy

↓

By inducing this it helps seeds to withstand desiccation & unfav. cond.

* Both Long day & Short day plant – can produce flower simultaneously in given place

* Cytokinin – cz senescence of leaf